Claims: What is claimed is:

1. A friction stir welding tool that is capable of functionally friction stir welding metal matrix composites (MMCs), ferrous alloys, non-ferrous alloys, and superalloys, said friction stir welding tool comprising:

a friction stir welding tool having a shank, a shoulder and a pin, wherein the shoulder is mechanically locked to the shank to thereby prevent rotational movement of the shoulder relative to the shank; and

a superabrasive material disposed on at least a portion of the shoulder and the pin, wherein the superabrasive material has a first phase and a secondary phase, wherein the superabrasive material is manufactured under an ultra high temperature and an ultra high pressure process, and wherein the friction stir welding tool is capable of functionally friction stir welding MMCs, ferrous alloys, non-ferrous alloys, and superalloys.

2. The tool as defined in claim 1 wherein the tool further comprises:

the shank being generally cylindrical, and having a shank working end and a shank attaching end, wherein the

shank attaching end is designed for coupling to a means for producing rotation, wherein the shank has a smaller diameter at the shank attaching end, and a larger diameter at the working end;

the shoulder being generally cylindrical and forming a disk, having a shoulder working end and a shoulder attaching end, wherein the shoulder has a diameter that is generally the same as the shank working end, and being coupled to the shank working end at the shoulder attaching end; and

the pin being an integral component of the shoulder, wherein the pin is generally cylindrical, wherein the pin is concentric with and parallel to a lengthwise axis of the shoulder from which it extends outwardly, and wherein a first pin radii is formed at a junction between the shoulder and the pin, and a second pin radii is formed at a pin working edge.

3. The tool as defined in claim 2 wherein the tool further comprises a locking collar, the locking collar performing the function of mechanically locking the

shoulder to the shank to thereby prevent rotational movement of the shoulder relative to the shank.

4. The tool as defined in claim 3 wherein the tool further comprises a first thermal flow barrier disposed between the shoulder and the shank to thereby regulate movement of heat from the shoulder to the shank.

5. The tool as defined in claim 4 wherein the tool further comprises a second thermal flow barrier disposed between the locking collar and the portion of the shoulder and the shank around which it is disposed, to thereby regulate movement of heat from the shoulder and the shank to the locking collar.

6. The tool as defined in claim 3 wherein the tool further comprises providing at least one surface feature disposed along a lengthwise axis of the tool, wherein the surface feature enables the locking collar to more securely restrain the shoulder and the shank in a same relative position.

7. The tool as defined in claim 6 wherein the tool further comprises selecting the at least one surface feature from the group of surface features comprising a flat, a spline, a keyway and key, a locking pin, a dovetail, and a dentation.

8. The tool as defined in claim 3 wherein the tool further comprises a mechanical lock between the shank working end and the shoulder attaching end, the mechanical lock being selected from the group of mechanical locks comprised of dovetails, splines, and dentations.

9. The tool as defined in claim 3 wherein the shoulder further comprises a shoulder radii disposed about a working edge thereof, the shoulder radii functioning as a crack inhibitor in the superabrasive material.

10. The tool as defined in claim 9 wherein the tool further comprises the shoulder radii being formed having a radius from 0.002" to 1.2", the range being selected to inhibit crack formation in the superabrasive material.

11. The tool as defined in claim 10 wherein the tool further comprises the first pin radii being formed having a radius from 0.002" to 3.5", the range being selected to inhibit crack formation in the superabrasive material.

12. The tool as defined in claim 11 wherein the tool further comprises the second pin radii being formed having a radius from 0.002" to 1.5", the range being selected to inhibit crack formation in the superabrasive material.

13. The tool as defined in claim 3 wherein the pin is selected as having a pin diameter to pin length ratio from 0.2:1 to 30:1.

14. The tool as defined in claim 3 wherein the tool further comprises the shoulder, wherein the first pin radii begins closer to the shank than the shoulder radii, such that a shoulder surface tapers inwards from the shoulder radii to the first pin radii to form an inverted frusto-conical shape.

15. The tool as defined in claim 3 wherein the tool

further comprises the shoulder, wherein the first pin radii begins closer to the shank than the shoulder radii, such that a shoulder surface tapers inwards from the shoulder radii to the first pin radii, and wherein the shoulder surface is concave.

16. The tool as defined in claim 3 wherein the tool further comprises the shoulder, wherein the first pin radii begins closer to the shank than the shoulder radii, such that a shoulder surface tapers inwards from the shoulder radii to the first pin radii, and wherein the shoulder surface is convex.

17. The tool as defined in claim 3 wherein the tool further comprises the shoulder, wherein a shoulder surface between the shoulder radii and the first pin radii forms a plane that is perpendicular to the lengthwise axis.

18. The tool as defined in claim 3 wherein the tool further comprises the shoulder, wherein the first pin radii begins further from the shank than the shoulder radii, such that a shoulder surface tapers outwards from

the shoulder radii to the first pin radii to form a frusto-conical shape.

19. The tool as defined in claim 3 wherein the tool further comprises the shoulder, wherein the first pin radii begins further from the shank than the shoulder radii, such that a shoulder surface tapers outwards from the shoulder radii to the first pin radii, and wherein the shoulder surface is concave.

20. The tool as defined in claim 3 wherein the tool further comprises the shoulder, wherein the first pin radii begins further from the shank than the shoulder radii, such that a shoulder surface tapers outwards from the shoulder radii to the first pin radii, and wherein the shoulder surface is convex.

21. The tool as defined in claim 15 wherein the tool further comprises the shoulder surface forming an angle between 0 degrees and 45 degrees from a plane that is perpendicular to the lengthwise axis.

22. The tool as defined in claim 18 wherein the tool further comprises the shoulder surface forming an angle between 0 degrees and 45 degrees from a plane that is perpendicular to the lengthwise axis.

23. The tool as defined in claim 3 wherein the tool further comprises the locking collar beginning at an inner radius, and tapering to an outer radius, and away from the pin, forming an angle that ranges from 0 degrees to 45 degrees.

24. The tool as defined in claim 2 wherein the means for mechanically locking the shoulder to the shank is selected from the group of mechanical locking means comprised of splines, locking pins, dovetails, and dentations.

25. A friction stir welding tool that is capable of friction stir welding metal matrix composites (MMCs), ferrous alloys, non-ferrous alloys, and superalloys, said friction stir welding tool comprising:

a shank having a shaft working end and a shaft attaching end, wherein a shank bore hole is disposed at

least partially into the working end, and wherein the shank bore hole is concentric with a lengthwise axis;

a shoulder having the form of a disk, wherein a shoulder hole is aligned with the shank bore hole, and wherein the shoulder is coupled to the shank, wherein the shoulder is mechanically locked to the shank, thereby preventing rotation of the shoulder relative to the shank;

a pin disposed through the shoulder hole and at least partially into the shank bore hole, wherein a portion of the pin is disposed outside the shoulder hole, and wherein the pin is mechanically locked to the shank, thereby preventing movement rotation of the pin relative to the shank; and

a superabrasive material disposed on at least a portion of the shoulder and the pin, and wherein the friction stir welding tool is capable of functionally friction stir welding MMCs, ferrous alloys, non-ferrous alloys, and superalloys.

26. The tool as defined in claim 25 wherein the tool further comprises:

the working end of the shank and the shoulder having an elliptical cross-section; and

a locking collar disposed around a portion of the shank and the shoulder, thereby preventing rotational movement of the shoulder relative to the shank.

27. The tool as defined in claim 28 wherein the tool further comprises the shoulder having a shoulder working edge, wherein the shoulder working edge has a radii to thereby inhibit crack formation in the superabrasive material.

28. The tool as defined in claim 27 wherein the tool further comprises a locking collar disposed around a portion of the shank and the shoulder, thereby preventing rotational movement of the shoulder relative to the shank.

29. The tool as defined in claim 28 wherein the tool further comprises a first thermal flow barrier disposed between the shoulder and the shank to thereby regulate movement of heat from the shoulder to the shank.

30. The tool as defined in claim 29 wherein the tool further comprises a second thermal flow barrier disposed between the locking collar and the portion of the shoulder and the shank around which it is disposed, to thereby regulate movement of heat from the shoulder and the shank to the locking collar.

31. The tool as defined in claim 30 wherein the tool further comprises a third thermal flow barrier disposed between the pin and the shank to thereby regulate heat flow within the tool.

32. The tool as defined in claim 31 wherein the tool further comprises providing at least one surface feature disposed along a lengthwise axis of the tool, wherein the surface feature enables the locking collar to more securely restrain the shoulder and the shank in a same relative position.

33. The tool as defined in claim 32 wherein the tool further comprises selecting the at least one surface feature from the group of surface features comprising a

flat, a spline, a keyway and key, a locking pin, a dovetail, and a dentation.

34. The tool as defined in claim 33 wherein the tool further comprises a mechanical lock between the shank working end and the shoulder attaching end, the mechanical lock being selected from the group of mechanical locks comprised of dovetails, splines, and dentations.

35. The tool as defined in claim 34 wherein the shoulder further comprises a shoulder radii disposed about a working edge thereof, the shoulder radii functioning as a crack inhibitor in the superabrasive material.

36. The tool as defined in claim 35 wherein the tool further comprises the shoulder radii being formed having a radius from 0.002" to 1.2", the range being selected to inhibit crack formation in the superabrasive material.

37. The tool as defined in claim 25 wherein the pin is selected as having a pin diameter to pin length ratio from 0.2:1 to 30:1.

38. The tool as defined in claim 36 wherein the tool further comprises the shoulder, wherein a shoulder surface tapers inwards from the shoulder radii to the pin to form a surface having an inverted frusto-conical shape.

39. The tool as defined in claim 38 wherein the tool further comprises the shoulder, wherein the surface is selected from the group of surfaces comprised of concave, convex, and linear.

40. The tool as defined in claim 36 wherein the tool further comprises the shoulder, wherein a shoulder surface between the shoulder radii and the pin forms a plane that is perpendicular to the lengthwise axis.

41. The tool as defined in claim 39 wherein the tool further comprises the shoulder surface forming an angle between 0 degrees and 45 degrees from a plane that is perpendicular to the lengthwise axis.

42. The tool as defined in claim 41 wherein the tool

further comprises the locking collar beginning at an inner radius, and tapering to an outer radius, and away from the pin, forming an angle that ranges from 0 degrees to 45 degrees.

43. The tool as defined in claim 25 wherein the shank further comprises a transition zone that divides the shaft working end and the shaft attaching end, wherein a diameter of the shank is altered at the transition zone.

44. The tool as defined in claim 43 wherein the shank further comprises the shank having the shaft attaching end larger in diameter than the shaft working end.

45. The tool as defined in claim 43 wherein the shank further comprises the shank having the shaft working end larger in diameter than the shaft attaching end.

46. A friction stir welding tool that is capable of friction stir welding metal matrix composites (MMCs), ferrous alloys, non-ferrous alloys, and superalloys, said friction stir welding tool comprising:

a shank having a shaft working end and a shaft attaching end, wherein a shank bore hole is disposed from the shaft working end to the shaft attaching end, and wherein the shank bore hole is concentric with a lengthwise axis;

a shoulder having the form of a disk, wherein a shoulder hole is aligned with the shank bore hole, and wherein the shoulder is coupled to the shank, wherein the shoulder is mechanically locked to the shank, thereby preventing rotation of the shoulder relative to the shank;

a pin disposed through the shoulder hole and at least partially into the shank bore hole, wherein a portion of the pin is disposed outside the shoulder hole, and wherein the pin is mechanically locked to the shank, thereby preventing movement rotation of the pin relative to the shank; and

a superabrasive material disposed on at least a portion of the shoulder and the pin, and wherein the friction stir welding tool is capable of functionally friction stir welding MMCs, ferrous alloys, non-ferrous alloys, and superalloys.

47. The tool as defined in claim 46 wherein the tool further comprises a locking collar disposed around a portion of the shank and the shoulder, thereby preventing rotational movement of the shoulder relative to the shank.

48. The tool as defined in claim 47 wherein the tool further comprises a first thermal flow barrier disposed between the shoulder and the shank to thereby regulate movement of heat from the shoulder to the shank.

49. The tool as defined in claim 48 wherein the tool further comprises a second thermal flow barrier disposed between the locking collar and the portion of the shoulder and the shank around which it is disposed, to thereby regulate movement of heat from the shoulder and the shank to the locking collar.

50. The tool as defined in claim 49 wherein the tool further comprises a third thermal flow barrier disposed between the pin and the shank to thereby regulate heat flow within the tool.

51. A friction stir welding tool that is capable of friction stir welding metal matrix composites (MMCs), ferrous alloys, non-ferrous alloys, and superalloys, said friction stir welding tool being a monolithic device comprising:

a shank having a shaft attaching end and a shaft working end;

a shoulder formed on the shaft working end, the shoulder having a shoulder working edge, wherein the shoulder working edge is formed as a radii;

a pin formed in the shoulder, wherein the pin is concentric with and parallel to a lengthwise axis of the shoulder from which it extends outwardly, and wherein a first pin radii is formed at a junction between the shoulder and the pin, and a second pin radii is formed at a pin working edge.

a superabrasive material disposed on at least a portion of the shoulder and the pin, and wherein the friction stir welding tool is capable of functionally friction stir welding MMCs, ferrous alloys, non-ferrous alloys, and superalloys.

52. A friction stir welding tool that is capable of friction stir welding metal matrix composites (MMCs), ferrous alloys, non-ferrous alloys, and superalloys, said friction stir welding tool comprising:

a shank having a shaft working end and a shaft attaching end, wherein a shank bore hole is disposed at least partially into the working end, and wherein the shank bore hole is concentric with a lengthwise axis;

a shoulder having the form of a disk, wherein a shoulder hole is aligned with the shank bore hole, and wherein the shoulder is coupled to the shank, wherein the shoulder is mechanically locked to the shank, thereby preventing rotation of the shoulder relative to the shank;

a pin disposed through the shoulder hole and at least partially into the shank bore hole, wherein a portion of the pin is disposed outside the shoulder hole, and wherein the pin is mechanically locked to the shank, thereby preventing movement rotation of the pin relative to the shank; and

a superabrasive material disposed on at least a portion of the shoulder and the pin, and wherein the friction stir welding tool is capable of functionally

friction stir welding MMCs, ferrous alloys, non-ferrous alloys, and superalloys.

53. The tool as defined in claim 52 wherein the tool further comprises the pin, wherein the pin has a cross-section that is an ellipsoid.

54. The tool as defined in claim 52 wherein the tool further comprises the pin, wherein the pin has a cross-section that is a polygon.

55. The tool as defined in claim 52 wherein the tool further comprises a junction between the pin and the shoulder is formed from the group of junctions including a radii and a chamfer, the junction being formed to inhibit cracks in the superabrasive material.

56. The tool as defined in claim 55 wherein the tool further comprises the pin, wherein the pin includes formations on a surface thereof, the formations causing fluid flow of a workpiece material around the pin to become transitional flow or turbulent flow.

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57. The tool as defined in claim 56 wherein the tool further comprises the pin, wherein the formations on the pin are a plurality of dimpled depressions on the surface thereof.

58. The tool as defined in claim 56 wherein the tool further comprises the pin, wherein the formation on the pin is a curved depression into a side thereof.

59. The tool as defined in claim 56 wherein the tool further comprises the pin, wherein the formation in the pin is a flat disposed into a side thereof.

60. A friction stir welding tool that is capable of functionally friction stir welding metal matrix composites (MMCs), ferrous alloys, non-ferrous alloys, and superalloys, said friction stir welding tool comprising:

a friction stir welding tool having a shank, a shoulder and a pin, wherein the shoulder is mechanically locked to the shank to thereby prevent rotational movement of the shoulder relative to the shank, and wherein the pin

is disposed so as to be offset from a lengthwise axis of the shank; and

a superabrasive material disposed on at least a portion of the shoulder and the pin, wherein the superabrasive material has a first phase and a secondary phase, wherein the superabrasive material is manufactured under an ultra high temperature and an ultra high pressure process, and wherein the friction stir welding tool is capable of functionally friction stir welding MMCs, ferrous alloys, non-ferrous alloys, and superalloys.

61. A friction stir welding tool that is capable of friction stir welding metal matrix composites (MMCs), ferrous alloys, non-ferrous alloys, and superalloys, said friction stir welding tool comprising:

a shank having a shaft attaching end and a shaft working end, the shaft having a bore hole disposed in the working end;

the shoulder being generally cylindrical and having an integral pin disposed thereon, wherein the shoulder has a diameter that is slightly greater than an inner diameter of the bore hole, wherein the shoulder is press fit into

the bore hole such that a wall of the bore hole functions as a locking collar;

a superabrasive material disposed on at least a portion of the shoulder and the pin, and wherein the friction stir welding tool is capable of functionally friction stir welding MMCs, ferrous alloys, non-ferrous alloys, and superalloys.

62. The tool as defined in claim 61 wherein the tool further comprises a thermal flow barrier disposed between the shoulder and the shank, to thereby control movement of heat therebetween.

63. The tool as defined in claim 72 wherein the thermal flow barrier further comprises titanium alloys.

64. The tool as defined in claim 72 wherein the tool further comprises a mechanical lock between the shank and the shoulder, the mechanical lock being selected from the group of mechanical locks comprised of dovetails, splines, and dentations.

65. A friction stir welding tool that is capable of functionally friction stir welding metal matrix composites (MMCs), ferrous alloys, non-ferrous alloys, and superalloys, said friction stir welding tool comprising:

a friction stir welding tool having a shank, a shoulder and a pin, wherein the shoulder is mechanically locked to the shank to thereby prevent rotational movement of the shoulder relative to the shank;

a thermal flow barrier disposed between the shank and the shoulder to thereby regulate movement of heat between the shank and the shoulder; and

a superabrasive material disposed on at least a portion of the shoulder and the pin, wherein the superabrasive material has a first phase and a secondary phase, wherein the superabrasive material is manufactured under an ultra high temperature and an ultra high pressure process, and wherein the friction stir welding tool is capable of functionally friction stir welding MMCs, ferrous alloys, non-ferrous alloys, and superalloys.

66. A method for friction stir welding metal matrix

composites (MMCs), ferrous alloys, non-ferrous alloys, and superalloys, said method comprising the steps of:

(1) providing a friction stir welding tool having a shank, a shoulder and a pin;

(2) mechanically locking the shoulder to the shank to thereby prevent rotational movement of the shoulder relative to the shank; and

(3) disposing a superabrasive material on at least a portion of the shoulder and the pin, wherein the superabrasive material has a first phase and a secondary phase, wherein the superabrasive material is manufactured under an ultra high temperature and an ultra high pressure process, and wherein the friction stir welding tool is capable of functionally friction stir welding MMCs, ferrous alloys, non-ferrous alloys, and superalloys.

67. The method as defined in claim 66 wherein the method further comprises the step of providing a first thermal barrier between the shoulder and the shank, whereby movement of heat between the shoulder and the shank is thereby regulated to improve characteristics of a friction stir weld.

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68. The method as defined in claim 66 wherein the method further comprises the step of reducing stress risers on the shoulder and on the pin, to thereby inhibit crack propagation of the superabrasive material.

69. The method as defined in claim 66 wherein the method further comprises the steps of:

(1) forming the shank as a generally object; and

(2) providing the shoulder as a disk-like object, wherein the pin is an integral component of the shoulder, wherein the pin is generally cylindrical, and wherein the pin is concentric with and parallel to a lengthwise axis of the shoulder from which it extends outwardly.

70. The method as defined in claim 69 wherein the method further comprises the step of providing a locking collar, the locking collar mechanically locking the shoulder to the shank to thereby prevent rotational movement of the shoulder relative to the shank.

71. The method as defined in claim 70 wherein the method

further comprises the step of disposing a second thermal flow barrier between the locking collar and a portion of the shoulder and the shank around which it is disposed, to thereby regulate movement of heat from the shoulder and the shank to the locking collar.

72. The method as defined in claim 71 wherein the method further comprises the step of regulating flow of heat within the friction stir welding tool by selecting a material for the thermal flow barrier that has a lower thermal conductivity than the shoulder, the pin and the locking collar.

73. The method as defined in claim 66 wherein the method further comprises the step of making an improved friction stir weld by providing a tool that inhibits materials from adhering to the friction stir welding tool during the welding process.

74. The method as defined in claim 66 wherein the method

further comprises the step of regulating a pin diameter to pin length ratio to thereby control characteristics of a weld.

75. The method as defined in claim 66 wherein the method further comprises the steps of:

(1) providing a shank having a shaft working end and a shaft attaching end, wherein a shank bore hole is disposed from the shaft working end to the shaft attaching end, and wherein the shank bore hole is concentric with a lengthwise axis;

(2) providing a shoulder having the form of a disk, wherein a shoulder hole is aligned with the shank bore hole, and wherein the shoulder is coupled to the shank, wherein the shoulder is mechanically locked to the shank, thereby preventing rotation of the shoulder relative to the shank; and

(3) providing a pin disposed through the shoulder hole and at least partially into the shank bore hole, wherein a portion of the pin is disposed outside the shoulder hole, and wherein the pin is mechanically locked

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to the shank, thereby preventing movement rotation of the pin relative to the shank.

76. The method as defined in claim 66 wherein the method further comprises the step of increasing a rate of flow of material around the pin during a friction stir welding process to thereby improve characteristics of a weld.

77. The method as defined in claim 76 wherein the method further comprises the step of creating transition flow or turbulent flow of material being welded around the pin.

78. The method as defined in claim 77 wherein the method further comprises the step of providing at least one surface deformation on the pin to thereby create the transitional or turbulent flow around the pin.

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